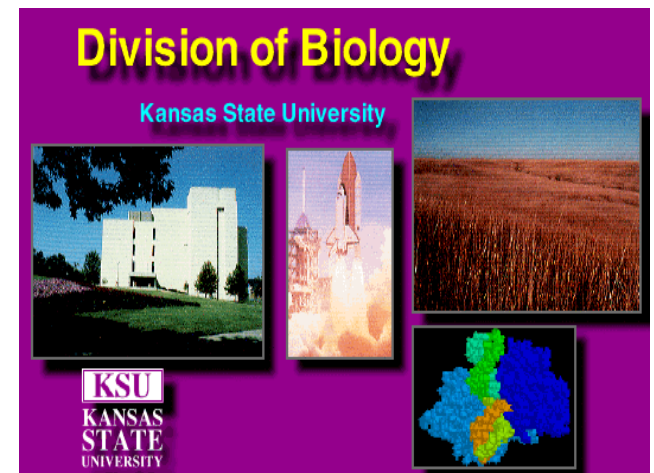


# Land Cover Change in the Great Plains: Predicting The Impact of Regional Forest Expansion on Biogeochemical Processes

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**COLLEGE OF AGRICULTURE**  
KANSAS STATE UNIVERSITY

# Research Objectives

- \* Assess the current and historic extent of red cedar forest using present-day and historic aerial photography and satellite imagery and a GIS database
- \* Quantify the effects of forest expansion on biogeochemical processescontrolling the storage, quantity, quality, and distribution of soil C and N cycling and availability
- \* Determine how the life form shifts alter ecosystem balance and fluxes of CO<sub>2</sub>, H<sub>2</sub>O, and energy
- \* Link spatially-explicit land cover change models to existing biogeochemical models to predict the ecosystem consequences of future forest expansion

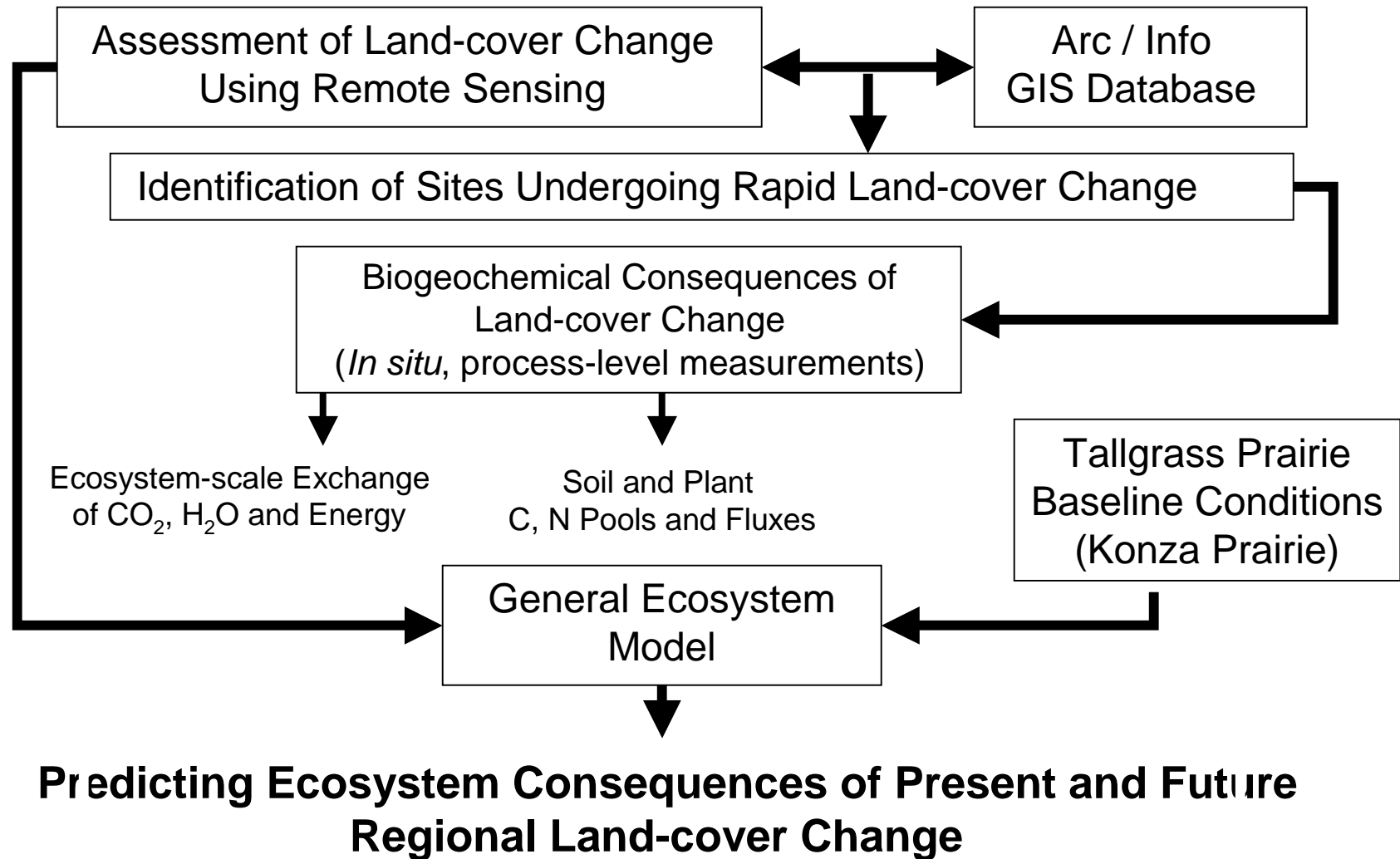
# Hypotheses

Land management, interacting with climatic variability, is the key factor controlling land-cover change at the forest-grassland ecotone in KS and perhaps the Great Plains and,

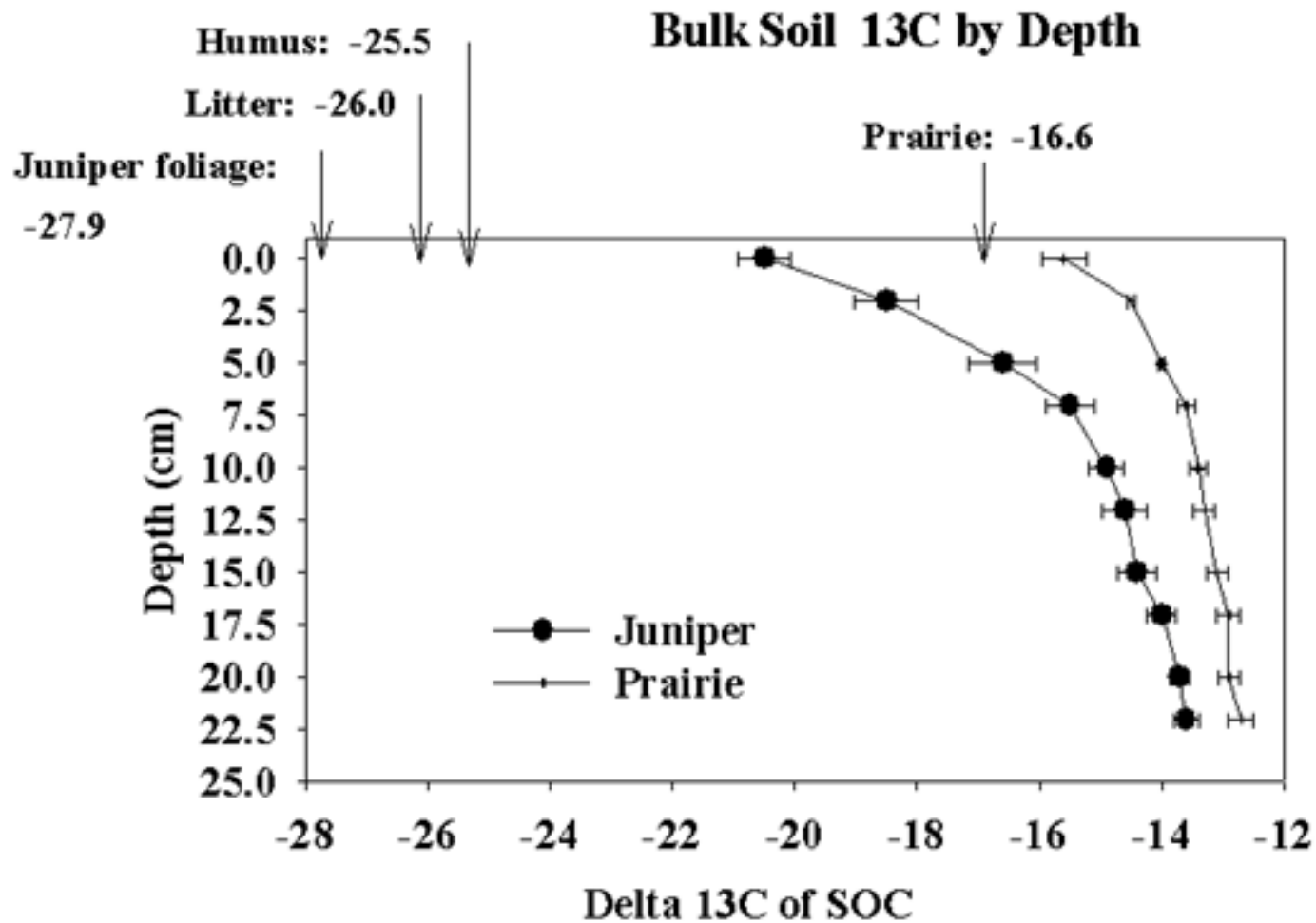
Fundamental changes in biogeochemical cycling and ecosystem function will accompany this land-cover change. Vegetation shifts can be expected to:

- 1) profoundly affect the quantity, quality, and distribution of plant C input to soil,
- 2) alter N availability and N cycling through vegetation-induced changes in C quality,
- 3) ultimately affect long-term soil C storage as soil organic matter and
- 4) alter ecosystem-scale fluxes of CO<sub>2</sub>, H<sub>2</sub>O and energy.

# Flow diagram showing the integration and interdisciplinary nature of the research program

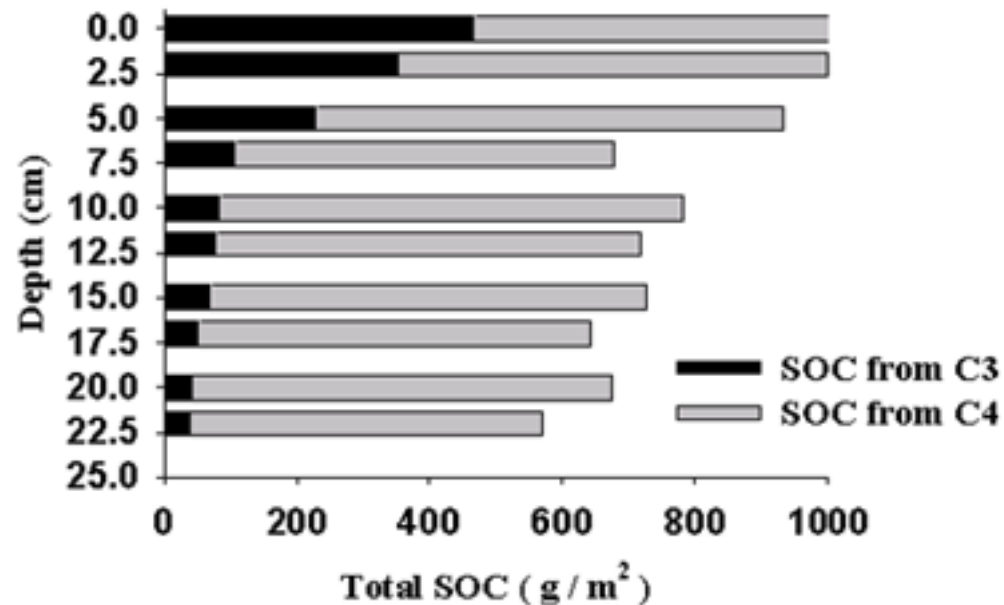


$\delta^{13}\text{C}$  reveals vegetation origin, forest or prairie, of soil organic carbon (SOC).



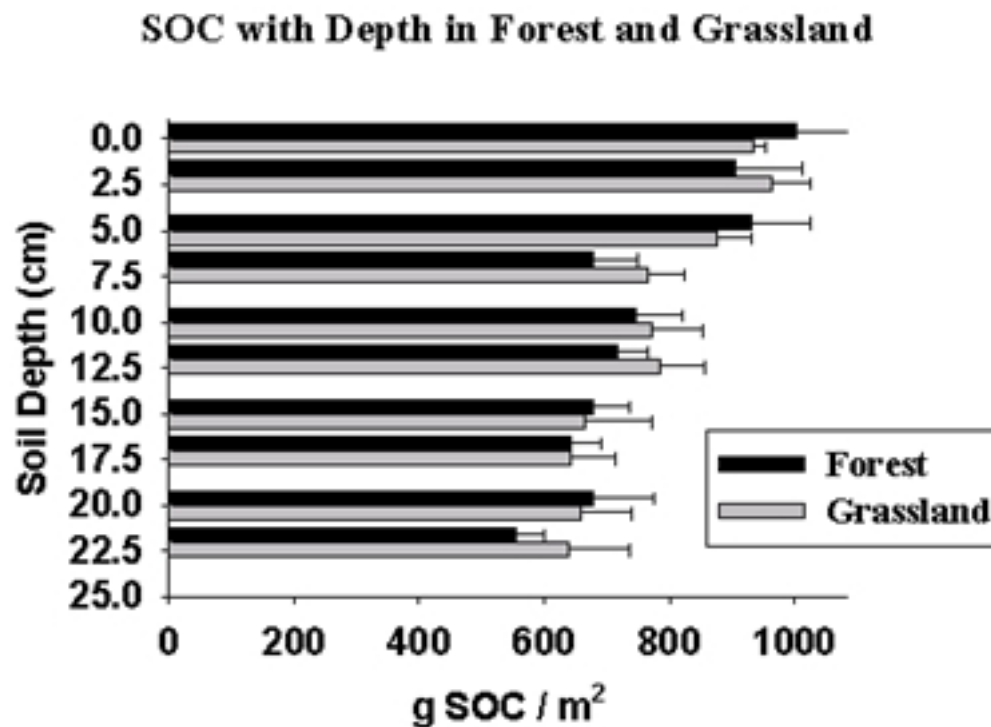
Based on changes in  $\delta^{13}\text{C}$  with depth and using soil bulk density, we estimate that forest carbon inputs already contributed about 20% of total SOC.

### Total Forest SOC from C3 and C4 Vegetation



Cumulative Forest SOC = 20 % Total  
1527 g C / m<sup>2</sup> C3 Forest vs. 6199 g C / m<sup>2</sup> C4 Grass

Regardless of vegetation, total SOC ( $\text{g}/\text{m}^2$ ) doesn't differ between forest and prairie. The accumulated humus and litter does contribute about  $1 \text{ kg}/\text{m}^2$ .

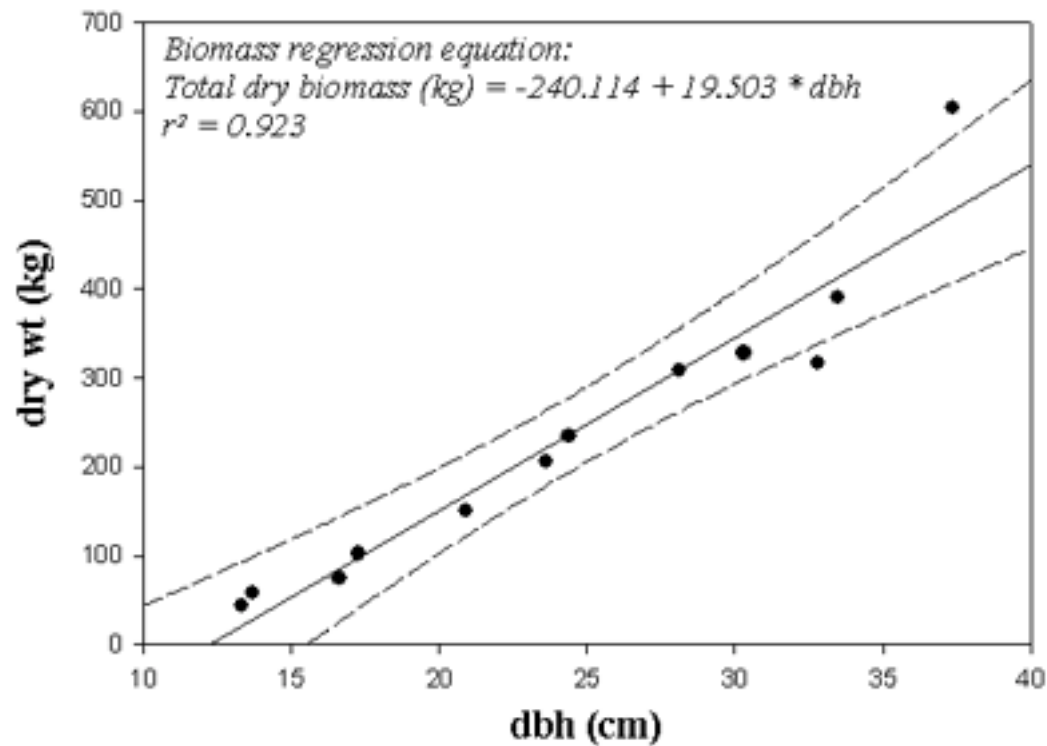


**Cumulative SOC**

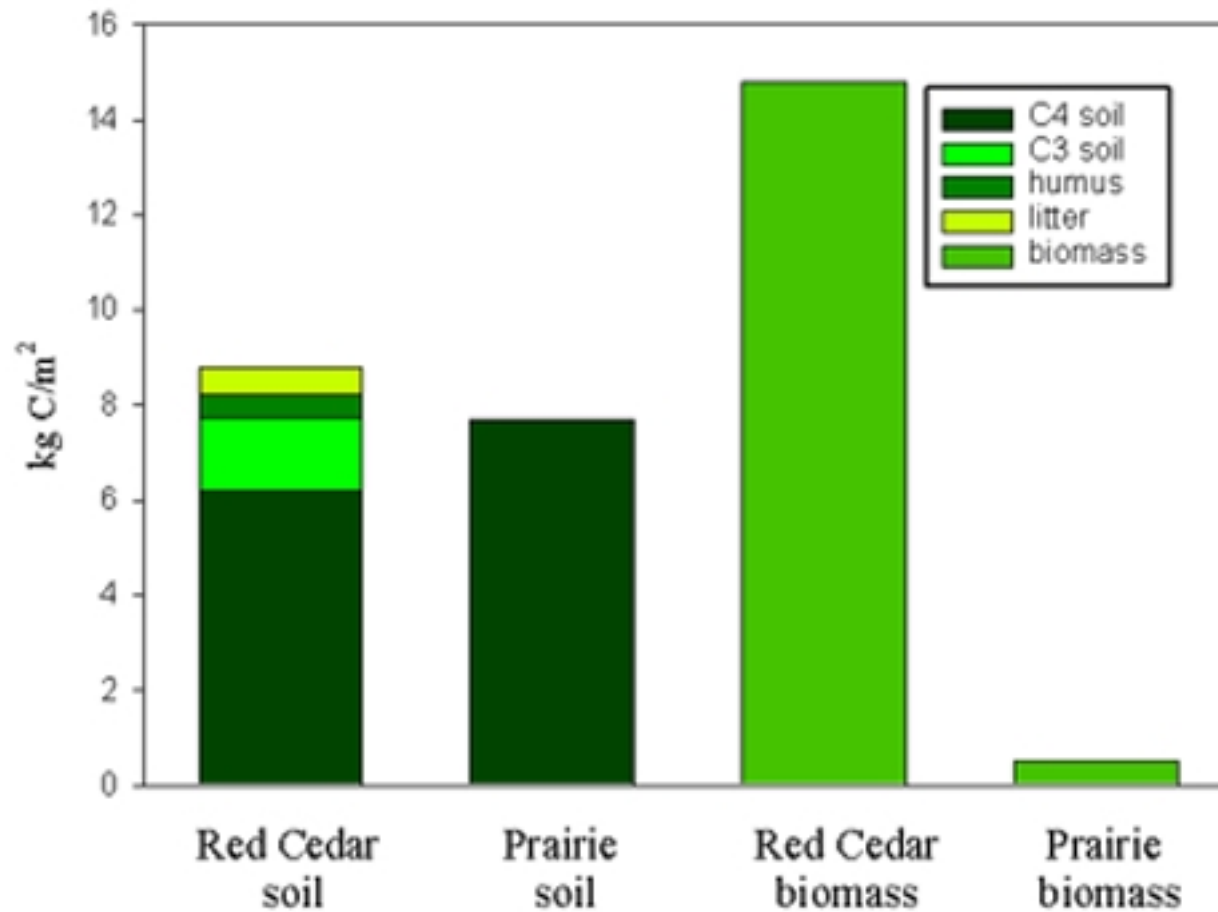
Forest Litter:	576.0 $\text{g C}/\text{m}^2$	Grass Litter:	0.0 $\text{g C}/\text{m}^2$
Humus:	481.0	Humus:	0.0
Soil:	7537.0	Soil:	7698.2
Total:	8594.0 $\text{g C}/\text{m}^2$	Total:	7698.2 $\text{g C}/\text{m}^2$

Allometric growth equations, tree density, and percent carbon can be used to determine aboveground biomass and carbon stocks.

**Biomass regression for eastern red cedar**  
**\*based on OK and KS data (n=12)**  
**(with 99% confidence intervals)**



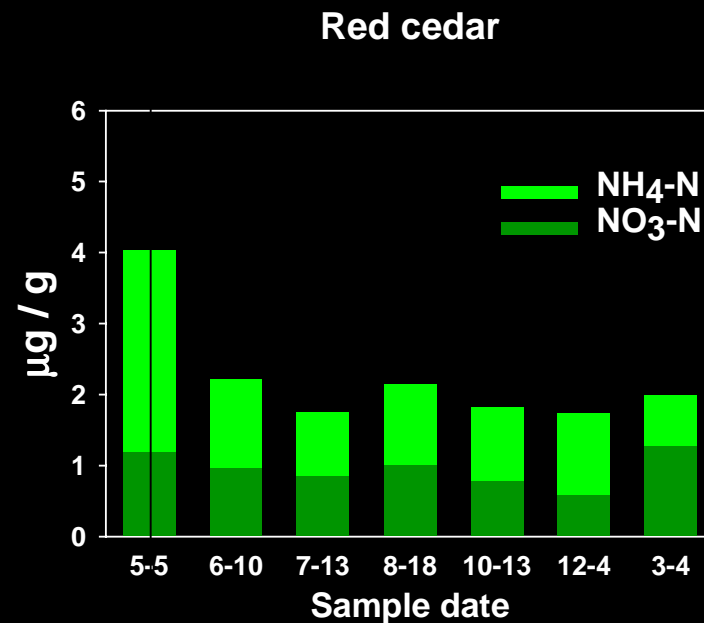
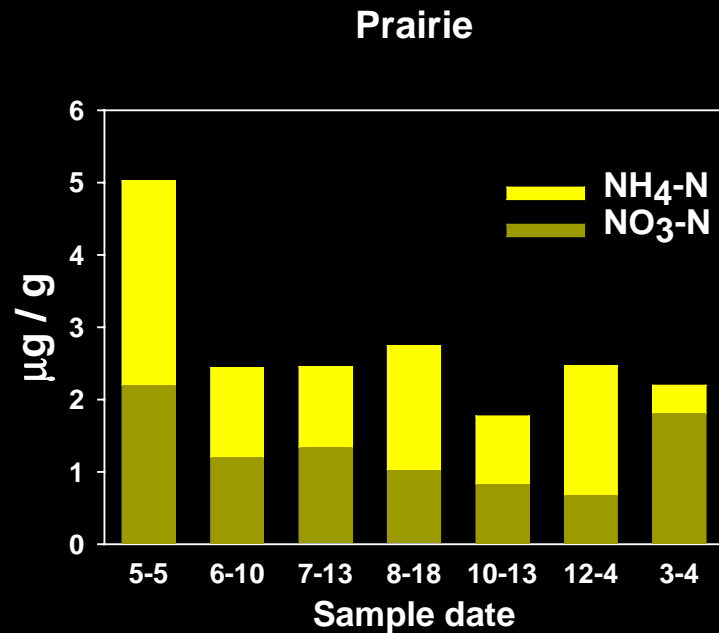
**The biggest effect of forest expansion on the carbon cycle is the accumulation and storage of C in aboveground biomass.**



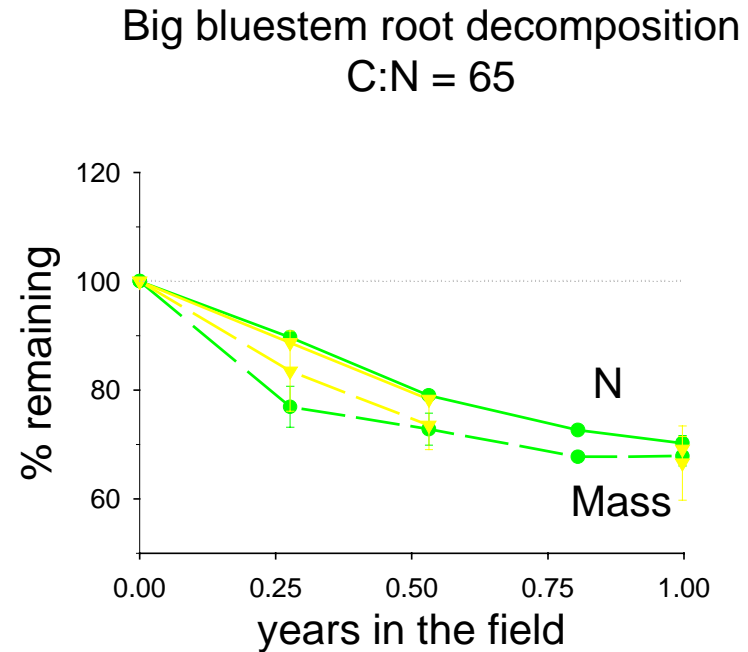
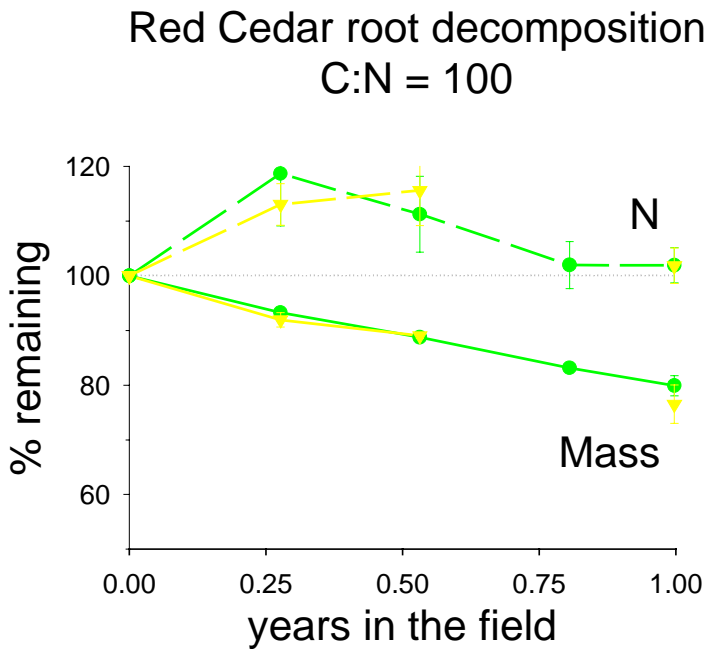
Based on data collected from the first 18 months of this project, we estimate that if forest expansion continues, it may result in up to 0.5-1.0 Pg C stored in these forests.

This C storage is at least regionally significant. Comparatively, continental US forests store approximately 12 Pg C.

**Forest expansion decreases N availability early in the spring relative to prairie, but by mid-summer N availability does not differ from prairie.**

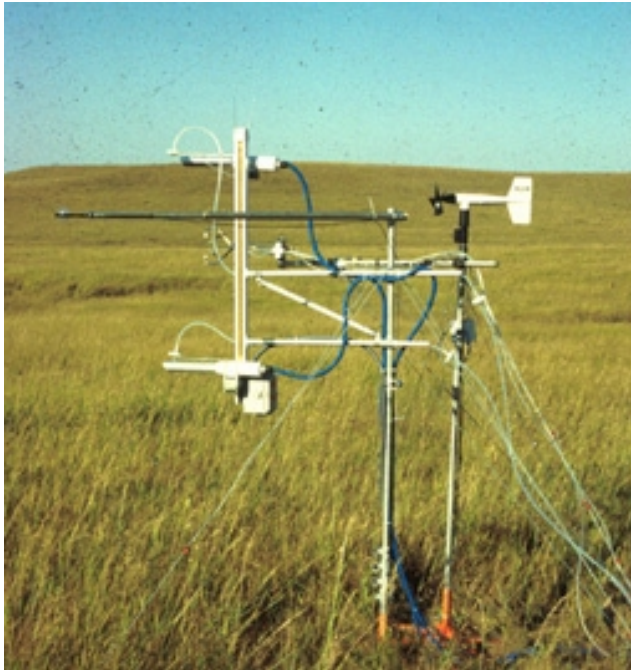


Litter decomposition is slower in the forests. This is primarily due to the quality of cedar litter, not microclimatic effects.



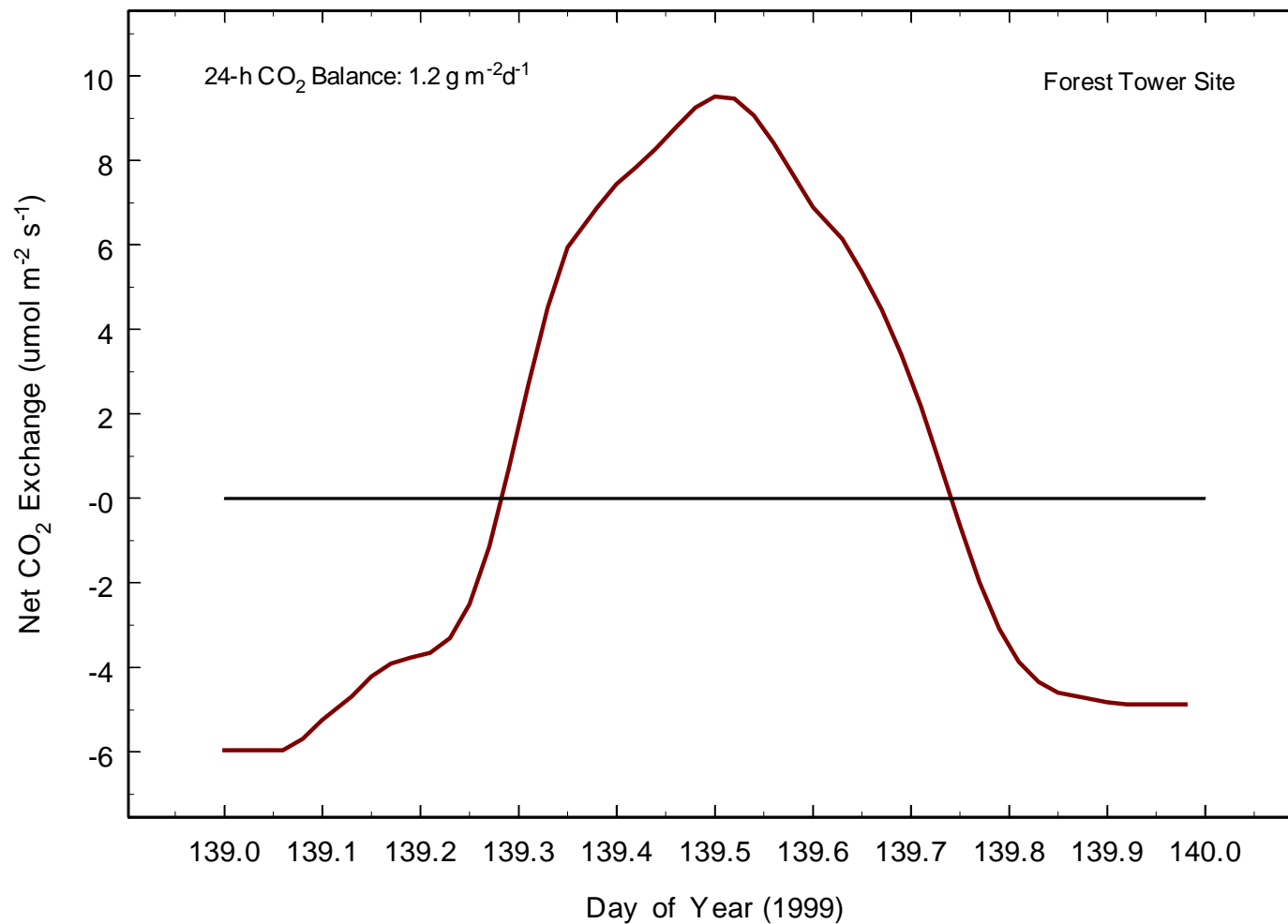
— Forest  
— Prairie

## Are forests sources or sinks for CO<sub>2</sub>?



Eddy Flux Towers in Prairie and  
Cedar Forest

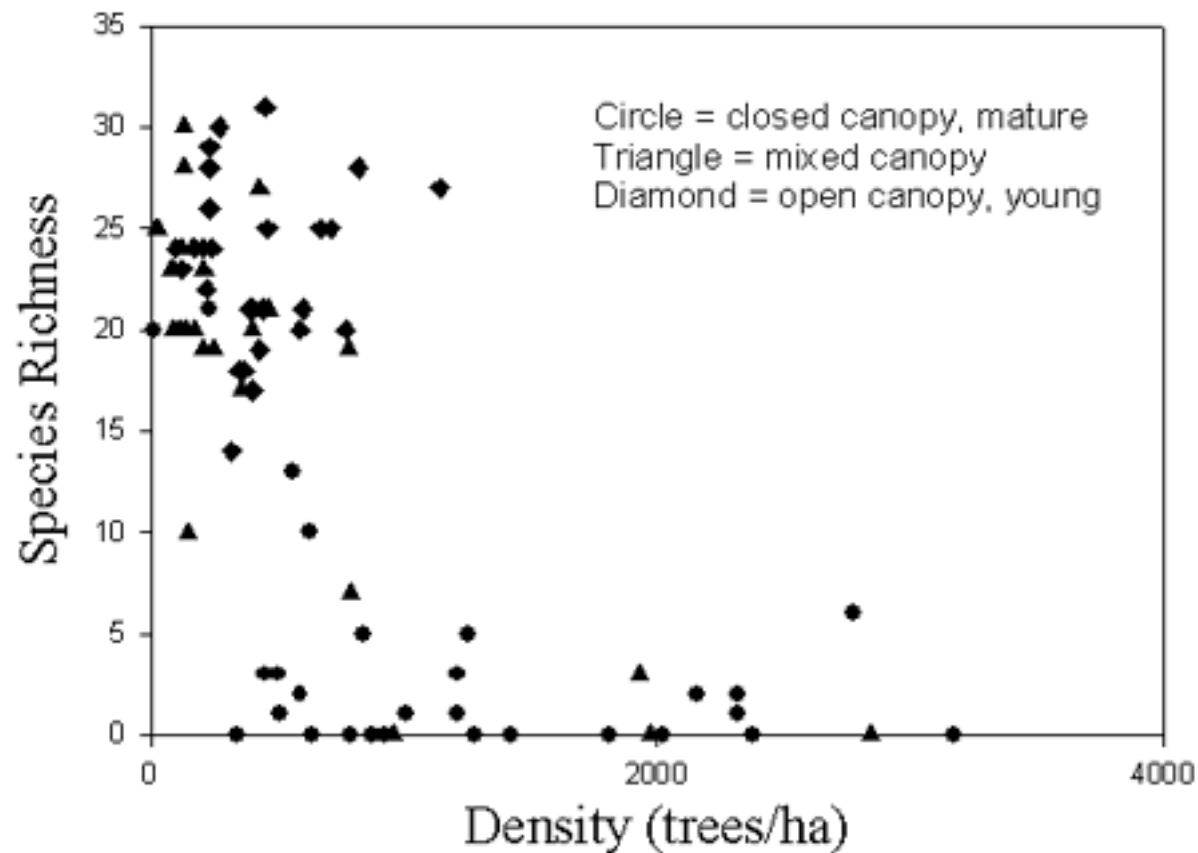
**Comparative grassland and forest data integrated over the year will indicate differences in net CO<sub>2</sub> exchange.**



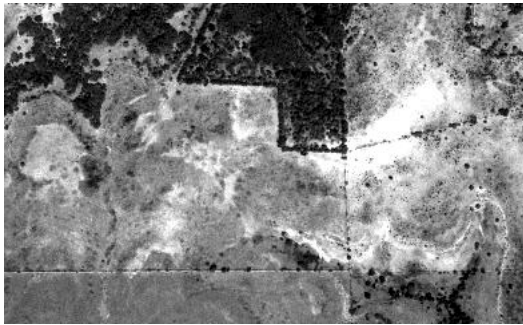
**Diurnal CO<sub>2</sub> Flux in Forest Site**

Forest expansion reduces herbaceous species diversity.

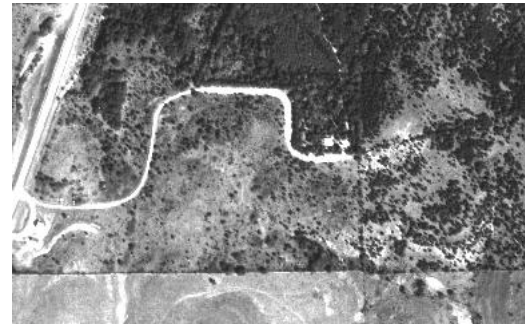
Herbaceous biomass in closed canopy forests is approximately 0.18 g/m<sup>2</sup> compared to 300-700 g/m<sup>2</sup> in prairie .



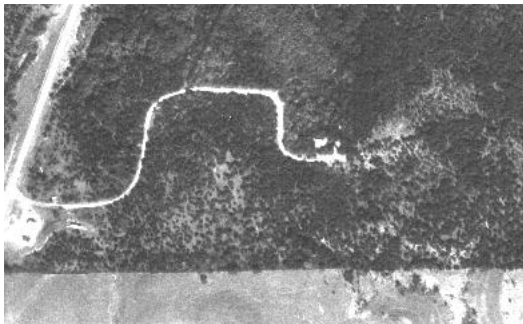
Using historic aerial photos we can determine rates of cedar expansion at fine scales.



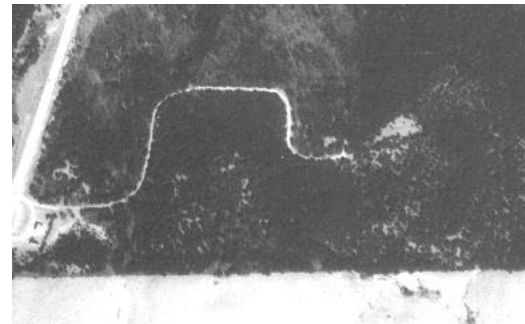
**1956**



**1969**



**1978**



**1996**

Images approximately 440 x 240 m

**Landsat TM images from northern extent of study area showing  
increase in cedar with arrows**

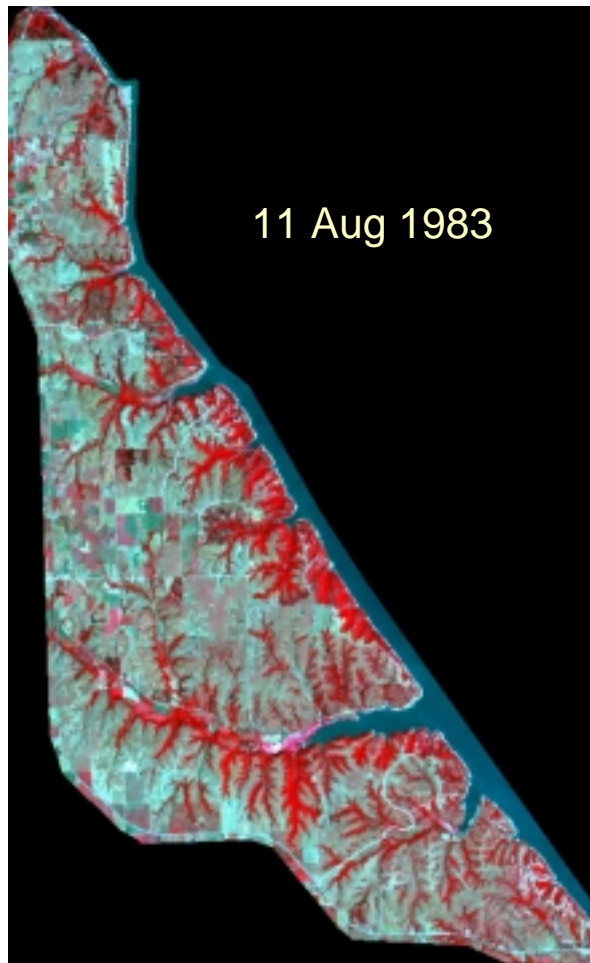
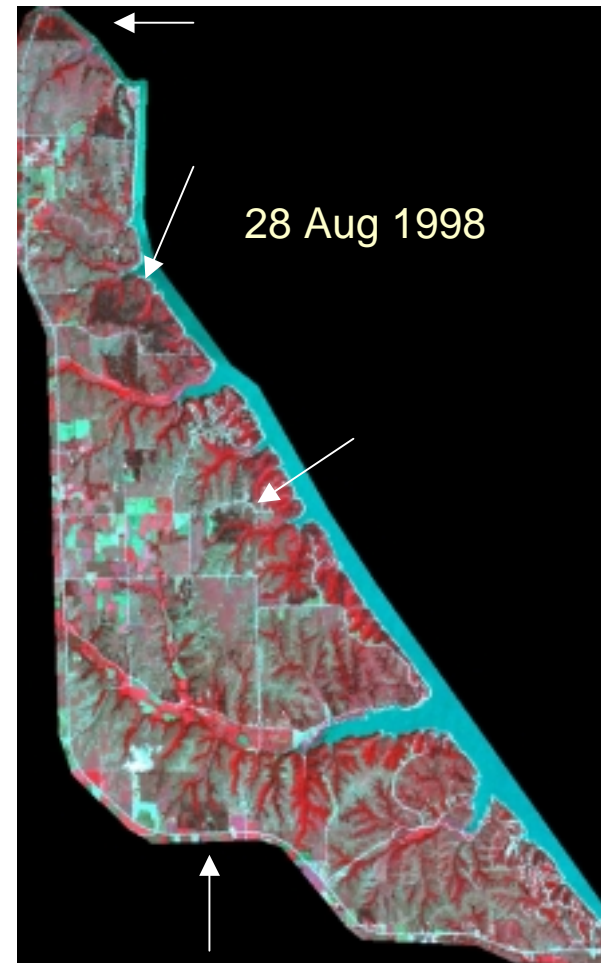
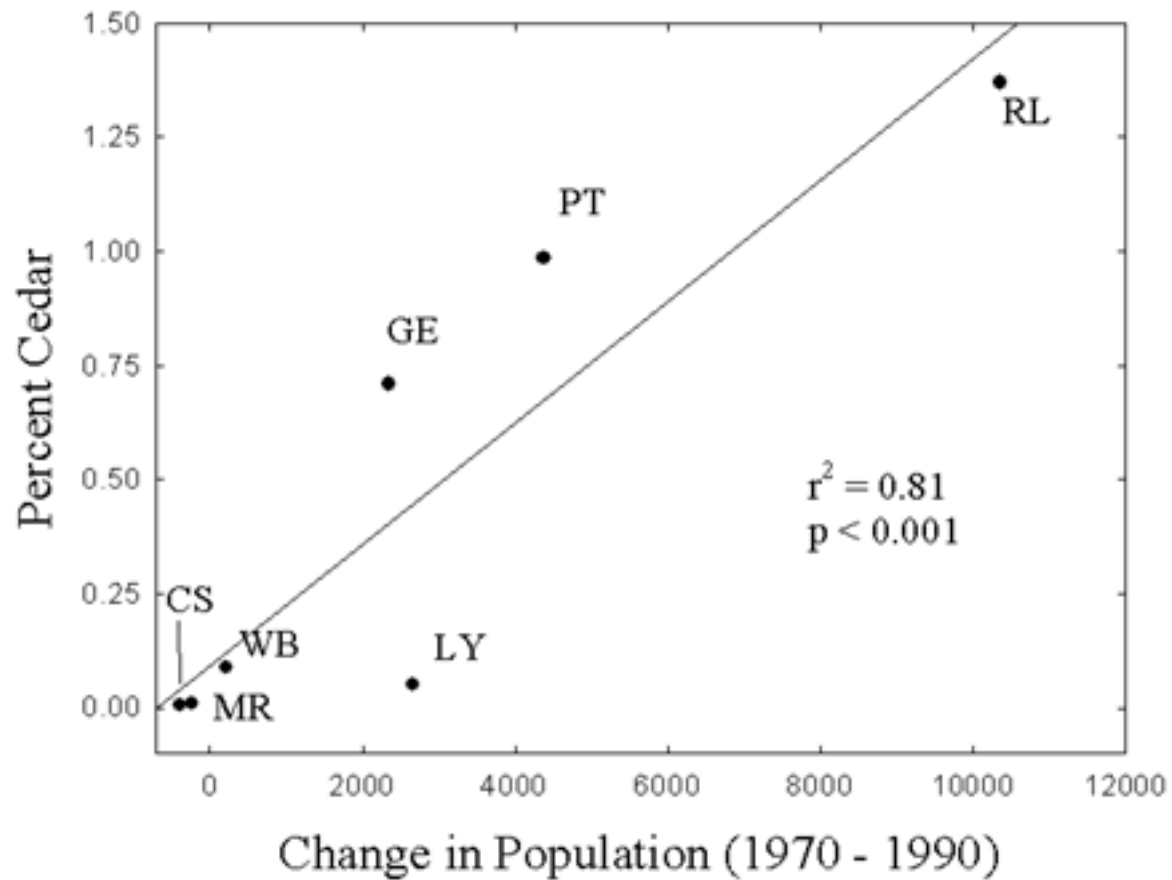


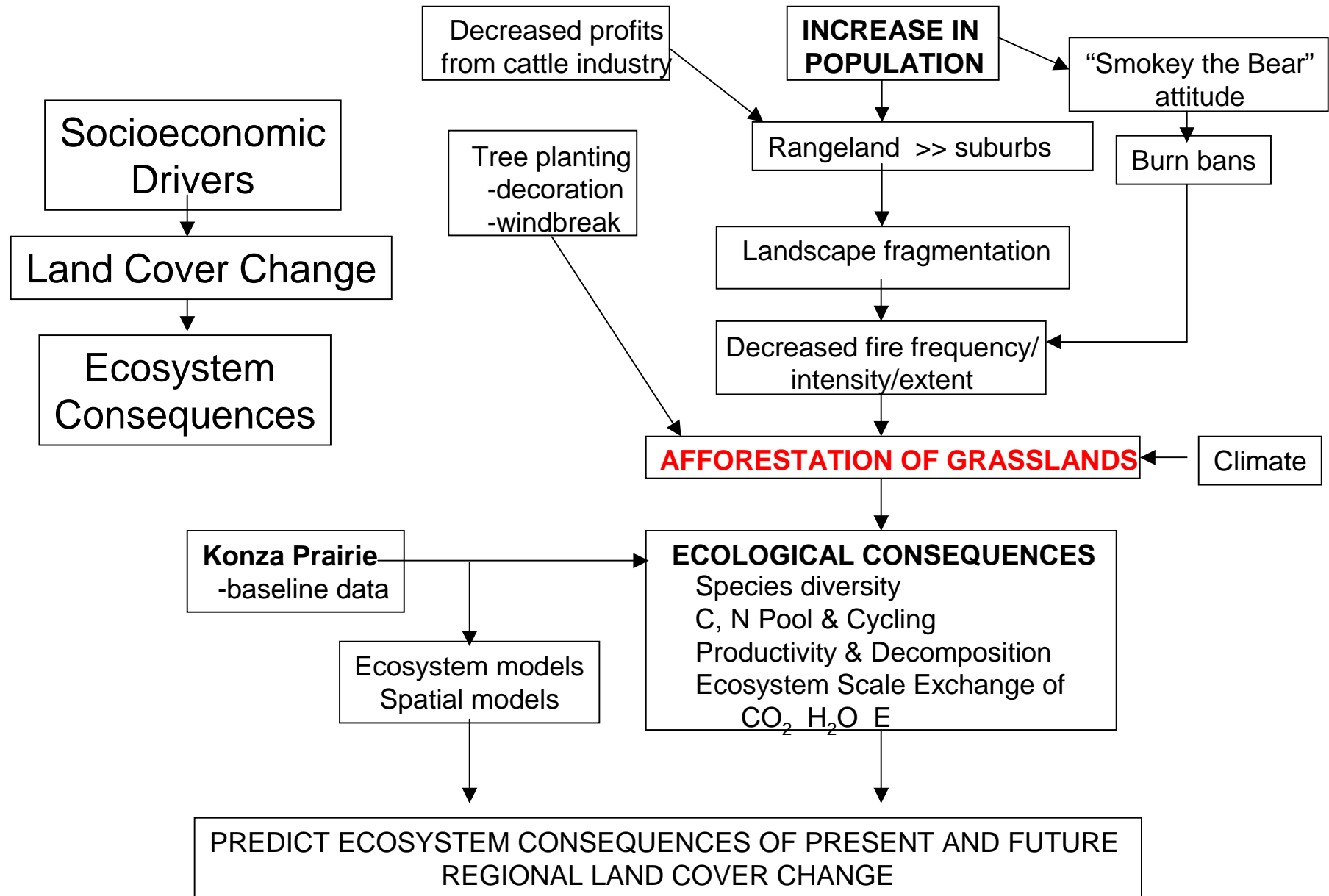
Image approximately 21 km N-S



## Relationship between population growth in counties (previous slide) and percent closed canopy red cedar forest



# Conceptual Model of Causes of Forest Expansion



## Next Steps:

1) We will use a linear spectral mixing model of the tasseled cap bands to identify partial canopy forests and measure rates of canopy closure from 1983 to 1998.

$$\text{Cedar83} = 97.78 - 0.886 * \text{Bright} - 0.370 * \text{Green} + 0.685 * \text{Wet}$$
$$r^2 = 0.90 \quad p = 0.0001$$

$$\text{Cedar98} = 262.9 - 1.856 * \text{Bright} - 0.272 * \text{Green} - 0.013 * \text{Wet}$$
$$r^2 = 0.73 \quad p = 0.0009$$

2) We will use our process-level biogeochemical results as input to our biogeochemical model (GEM) to predict ecosystem consequences of regional forest expansion.

